Biological and Clinical Sciences Research Journal
eISSN: 2708-2261; pISSN: 2958-4728
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v6i6.1790
*Biol. Clin. Sci. Res. J., Volume 6(6), **2025**: 1790*
Original Research Article

Prognostic Power of Cerebroplacental Ratio for Adverse Fetal Outcomes in Women with High-Risk Pregnancies

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(Received, 24th March 2025, Accepted 18th June 2025, Published 30th June 2025)

Abstract: *High-risk pregnancies are associated with increased risk of adverse fetal outcomes, including perinatal mortality and morbidity. The cerebroplacental ratio (CPR), derived from Doppler assessment of fetal umbilical artery (UA) and middle cerebral artery (MCA) pulsatility indices (PIs), has been proposed as a non-invasive predictor of such outcomes. However, its predictive accuracy remains variable in clinical practice.* ***Objective:*** *To evaluate the predictive ability of cerebroplacental ratio for adverse fetal outcomes in women with high-risk pregnancies.* ***Methods:*** *This retrospective study was conducted in the Department of Obstetrics and Gynaecology at Nishtar Hospital, Multan, from February 2024 to February 2025. A total of 100 pregnant women with singleton pregnancies between 32 and 40+6 weeks of gestation were included. All participants underwent Doppler ultrasonography to assess UA-PI, MCA-PI and to calculate the CPR. The primary outcome was the incidence of perinatal adverse outcomes such as stillbirth, neonatal death, low 5-minute Apgar score, seizures, and grade II or III neonatal encephalopathy. Secondary outcomes included the incidence of small-for-gestational-age (SGA) fetuses among live births, SGA fetuses with morbidity, and morbidity in appropriate-for-gestational-age (AGA) fetuses. Data were analyzed using receiver operating characteristic (ROC) curves, and area under the curve (AUC) values were compared.* ***Results:*** *UA-PI, MCA-PI, and CPR were all poor predictors of perinatal mortality, with AUCs of 0.61, 0.55, and 0.58, respectively, showing no significant difference in accuracy. For the prediction of SGA fetuses, CPR demonstrated a significantly higher z-score (0.75) compared to MCA-PI (0.71) and UA-PI (0.72). CPR and MCA-PI both had moderate predictive value for morbidity in AGA fetuses (AUC: 0.65), outperforming UA-PI (AUC: 0.58). For morbidity prediction in SGA fetuses, CPR (AUC: 0.76) and MCA-PI (AUC: 0.75) exhibited similar prognostic accuracy, both superior to UA-PI (AUC: 0.65).* ***Conclusion:*** *While Doppler indices including CPR, MCA-PI, and UA-PI demonstrated limited utility in predicting perinatal mortality, CPR and MCA-PI were relatively better predictors of neonatal morbidity, particularly in small-for-gestational-age fetuses. These findings support the clinical value of CPR and MCA-PI in fetal surveillance during high-risk pregnancies.*

Keywords: Apgar Score, Cerebroplacental Ratio, Fetal Growth Restriction, Pregnancy, High-Risk, Ultrasonography, Doppler

[***How to Cite:*** Batool S, Bhatti R, Sahar A. Prognostic power of cerebroplacental ratio for adverse fetal outcomes in women with high-risk pregnancies. *Biol. Clin. Sci. Res. J.*, **2025;** 6(6): 4-7. doi: https://doi.org/10.54112/bcsrj.v6i6.1790

Introduction

Fetal growth restriction is a common obstetrics complication that negatively impacts perinatal outcome and significantly increases morbidity.(1)The outcome of patients with FGR is also influenced by duration of labor, mode of delivery and clinical management. The results are worst in AGA fetuses with brain sparing.(2, 3)

Perinatal mortality and risk of c-section in high-risk pregnancies is associated with measurement of pulsatility index of umbilical artery and middle cerebral artery. Cerebroplacental ratio is used as a strong predictor of fetal outcomes especially in patients with possible fetal growth restriction.(4, 5)The ratio between pulsatility index of umbilical artery and middle cerebral artery predicts the blood supply to fetal brain and placental resistance. Although, there has been vast evidence regarding accuracy of CPR, it has yet not been used as standard factor in clinical practice.

This study was conducted to evaluate the predictive ability of cerebroplacental ratio for adverse fetal outcomes in women with high-risk pregnancies.

Methodology

A retrospective study was conducted in the Gynecology and Obstetrics Department of Nishtar Hospital, Multan from February 2024 to February 2025. A total of 100 pregnant women with singleton pregnancies who underwent doppler ultrasound between 32 and 40+6 gestational weeks. Women with multiple pregnancies, fetal abnormalities, chromosomal disorders, fetal arrythmias, isoimmunization, ARED flow in umbilical artery and those with gestation age of 42 or more weeks at delivery were excluded.

Patients were divided into two groups; Group A included patients that underwent vaginal and intrapartum c-sections while Group B included patients who underwent spontaneous labor onset. All patients with current or history of preeclampsia, suspicion of fetal growth restriction, pregestational diabetes, amniotic fluid abnormalities, concomitant maternal diseases and reduced fetal movements underwent Doppler examinations. Baseline maternal information, including BMI, gestation age and medical conditions, was noted.

The Umbilical Artery Pulsatility Index was measured at a free-floating segment of the umbilical cord during fetal rest at an angle <30 degrees. The middle cerebral artery Pulsatility Index was measured by scanning across the fetal head at a standard level to see the middle cerebral artery clearly closest to the transducer. Doppler sample gate was placed near the origin of MCA, close to the internal carotid artery, after identifying the circle of Willis using color Doppler in an axial view of the fetal head.

The primary outcome was incidence of perinatal adverse outcomes(asphyxia/ mortality) such as stillbirth, death, low 5-mint Apgar score, seizures and grade II & III encephalopathy. The secondary outcomes were incidence of small for gestation age fetuses in live fetuses, small for gestation age fetuses with morbidity and appropriate for gestation age live fetuses with morbidity. Morbidity included NICU admission, transient tachypnea, meconium aspiration syndrome, pulmonary hypertension, bronchopulmonary dysplasia, need for

ventilation, seizures, periventricular leukomalacia and grade III & IV intraventricular hemorrhage.

All data was analyzed by SPSS 22. Demographic data was presented as n (%) or median (range) where applicable. ROC curves were plotted for assessing the accuracy of CPR and pulsatility index of umbilical artery and middle cerebral artery.

Results

A total of 100 women were included in analysis with the median age of 29 (15-47) years. The median gestation age at birth was 38 weeks and 6 days with 53% between 37 and 39 weeks. 22 (22%) patients underwent c-section before labor and 35 (35%) underwent emergent c-section. The average time between doppler examination and delivery was 4 days. Majority of neonates (96%) had good Apgar score except 4 (4%) with 0-6 score. 45 (45%) neonates were small for gestation age and 4 (4%) died during stay among which only 1 (1%) died after delivery. 15% of the fetuses with appropriate or large for gestational age and 28% of small for gestation age suffered morbidity. The maternal and neonatal data of study participants is shown in Tables I and II.

All the three variables, UA-PI, MCA-PI and CPR were poor predictors of perinatal mortality with area under the curve of 0.61, 0.55, 0.58 on the ROC curve with no significant difference in accuracy (Table III). In Group A, the respective values were 0.59, 0.49 and 0.59 with a significant difference of p=0.010. The Group B showed that UA-PI had a significantly high score of 0.61 as compared to 0.45 of MCA-PI and 0.55 of CPR.

For prediction of small for gestation age, CPR had a significantly high z-score of 0.75 as compared to MCA-PI (0.71) and UA-PI (0.72). CPR and MCA-PI were similar (AUC:0.65) and better predictors of morbidity in large or appropriate for gestation age than UA-PI (AUC: 0.58). The prognostic accuracy for morbidity in SGA fetuses was same for CPR (AUC: 0.76) and MCA-PI (AUC: 0.75) which was significantly better than UA-PI (AUC: 0.65).

Table I: Maternal personal and obstetrics characteristics

Characteristics	**N (%)**
Median maternal age	29 (15-47)
Younger than 20 years	45 (45%)
35 years or older	55 (55%)
Median maternal BMI	24.1 (16.6-49)
Less than 18.5 kg/ m2	5 (5%)
30 kg/m2 or more	13 (13%)
Nulliparity	60 (60%)
Gestation age at delivery	38^{+6} (32^{+0} – 41^{+6})
32-33 weeks	10 (10%)
34-26 weeks	26 (26%)
37-39 weeks	53 (53%)
40-41 weeks	11 (11%)
Delivery	
Spontaneous labor	50 (50%)
Labor induction	28 (28%)
Intrapartum cesarean section	22 (22%)
Mode of delivery	
Operative vaginal	55 (55%)
Emergency cesarean section	35 (35%)
Elective cesarean section	10 (10%)
Days between doppler and delivery	4 (0-12)
5-mint Apgar score	10 (0-10)
0-3	1 (1%)
4-6	3 (3%)
7-10	96 (96%)
Birth weight	2500 (1031-5238)

Table II: Neonatal data

Outcomes	**N (%)**
Stillbirths	1 (1%)
Low 5-mint Apgar score	4 (4%)
Small for gestation age	45 (45%)
NICU admission	44 (44%)
Bronchopulmonary dysphagia	2 (2%)
Respiratory distress	2 (2%)
Transient tachypnea	2 (2%)
Pulmonary hypertension	1 (1%)
Meconium aspiration syndrome	**-**
Intraventricular hemorrhage	1 (1%)
Seizures	1 (1%)
Encephalopathy	1 (1%)
Mortality	1 (1%)

Secondary outcomes	
Perinatal asphyxia/mortality	4 (4%)
Large/ appropriate for gestation age live fetuses with morbidity	15 (15%)
Small for gestation age live fetuses with morbidity	28 (28%)

Table III: Predictive accuracy of Cerebroplacental Ratio and Pulsatility Indices

	Umbilical artery pulsatility index z-score		**Middle cerebral artery pulsatility index z-score**		**Cerebroplacental ratio z-score**		**P value**	
	AUC	**95% CI**	**AUC**	**95% CI**	**AUC**	**95% CI**	**CPR vs UA-PI**	**CPR vs MCA-PI**
Perinatal asphyxia/mortality	0.61	0.51-0.65	0.55	0.47-0.59	0.58	0.51-0.66	0.41	0.079
Healthy small for gestation age fetuses	0.73	0.68- 0.75	0.70	0.66-0.69	0.76	0.69-0.77	<0.001	<0.001
Large/ appropriate for gestation age live fetuses with morbidity	0.61	0.49-0.62	0.66	0.62-0.72	0.66	0.62-0.71	<0.001	0.46
Small for gestation age live fetuses with morbidity	0.58	0.60-0.68	0.76	0.69-0.81	0.77	0.69-0.77	<0.001	0.50

Discussion

This study was conducted in assess the predictive ability of cerebroplacental ratio and its pulsatility indices for adverse outcomes in high-risk pregnancies bearing term and preterm fetuses. The results showed that Doppler measurement had poor predictive power for neonatal mortality or asphyxia, however, CPR and MCA-PI were good predictors of neonatal morbidity especially in small for gestational age fetuses. These findings are similar to previous data.(6, 7)

Cerebroplacental ratio was a significantly stronger predictor of small birth weight than other doppler measures. The difference between area under the curve was small but was statistically significant, requiring more investigating for its clinical importance. We did not evaluate association between other predictors of SGA like estimated fetal weight. A previous study reported EFW was significantly better at predicting SGA in third trimester than Doppler measurements.(8)

CPR has been showed to be an important risk factor for fetal hypoxia for three decades. In women at a risk of fetal growth restriction, it showed promising outcomes to predict adverse fetal outcomes in early studies.(9, 10) This implied that it may be a predictor of hypoxia in late pregnancy since umbilical artery pulsatility index did not show satisfactory results due to large volume of placenta inducing changes in the contents of umbilical artery. However, CPR was not impacted by the changes in UA-PI as it could show the fetal blood flow redistribution as a result of hypoxia.

Various studies have showed CPR as strong determinant of outcomes such as need for emergent cesarean section and NICU admission.(11, 12)Recent research also suggests using CPR and mean UA-PI with fetal biometry, where necessary for estimating incidence of still births and mortality after birth.(13) On the other hand, the clinical application of CPR has been not been recognized by majority of studies especially after 34 weeks gestational age.(14) Recent large studies in women with 30-34 weeks gestation and 35-37 weeks age concluded a strong relationship between CPR and small gestation age fetuses but it was a poor indictor of adverse outcomes, similar to our study.(15, 16)

Conclusion

Doppler measurement had poor predictive power for neonatal mortality or asphyxia, however, CPR and MCA-PI were good predictors of neonatal morbidity especially in small for gestational age fetuses.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-24)

Consent for publication
Approved

Funding
Not applicable

Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

SB (WMO)
Manuscript drafting, Study Design,
RB (WMO)
Review of Literature, Data entry, Data analysis, and drafting articles.
AS (SWMO)
Conception of Study, Development of Research Methodology Design,

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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